

IN THE UNITED STATE PATENT AND TRADEMARK OFFICE

  
In re application of : Confirmation No. 6129  
Kaoru YAMADA et al. : Docket No. 2006-0044A  
Serial No. 10/564,980 : Group Art Unit 1792  
Filed January 18, 2006 : Examiner WALDBAUM, SAMUEL A  
SUBSTRATE PROCESSING APPARATUS,  
SUBSTRATE PROCESSING METHOD, AND  
SUBSTRATE HOLDING APPARATUS

**VERIFYING DECLARATION**

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Sir:

I, Tetsuya Hirosawa, declare and say:  
that I am thoroughly conversant in both the Japanese and English languages;  
that I am presently engaged as a translator in these languages;  
that the attached document represents a true English translation of Japanese  
Patent Application No. 2003-317395 filed on September 9, 2003.

I further declare that all statements made herein of my own knowledge are true  
and that all statements made on information and belief are believed to be true; and  
further that these statements were made with the knowledge that willful false statements  
and like so made are punishable by fine or imprisonment, or both, under Section 1001 of  
Title 18 of the United States Code, and that such willful false statements may jeopardize  
the validity of the application or any patent issuing thereon.

Signed this 20th day of February, 2009

  
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TRANSLATOR

(THE NAME OF DOCUMENT) PATENT APPLICATION  
(REFERENCE NUMBER) EB3180P  
(FILING DATE) September 9, 2003  
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(INTERNATIONAL PATENT CLASSIFICATION) B23Q 03/06  
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(REGISTERED NUMBER FOR PAYMENT) 026996

(AMOUNT) 21000

(LIST OF DOCUMENT FILED)

(THE NAME OF DOCUMENT) CLAIMS 1

(THE NAME OF DOCUMENT) SPECIFICATION 1

(THE NAME OF DOCUMENT) DRAWINGS 1

(THE NAME OF DOCUMENT) ABSTRACT 1

(THE NUMBER OF GENERAL POWER OF ATTORNEY) 9112447

(THE NUMBER OF GENERAL POWER OF ATTORNEY) 0018636

(NAME OF DOCUMENT)

CLAIMS

(CLAIM 1)

A substrate holding apparatus for holding a substrate, comprising:

a plurality of rollers which are brought into contact with an edge portion of a substrate so as to hold and rotate the substrate,

wherein said rollers are movable in a radial direction of the substrate.

(CLAIM 2)

A substrate holding apparatus according to claim 1, wherein said rollers are disposed at equal intervals in a circumferential direction of the substrate.

(CLAIM 3)

A substrate holding apparatus according to claim 1 or 2, at least one of said rollers presses the edge portion of the substrate toward a center of the substrate while rotating the substrate.

(CLAIM 4)

A substrate holding apparatus according to any one of claims 1 to 3, wherein each of circumferential surfaces of said rollers has a groove-like clamp portion which is brought into contact with the edge portion of the substrate, and a width of said clamp portion is not more than twice a thickness of the substrate.

(CLAIM 5)

A substrate holding apparatus according to claim 4, wherein said clamp portion has a flat section positioned centrally in said clamp portion and two curved sections positioned adjacent to upper and lower ends of said flat section, and a width of said flat section is not more than half the thickness of the substrate.

(CLAIM 6)

A substrate holding apparatus according to claim 1, wherein distances between contact points where three of said rollers are held in contact with the substrate are smaller than a diameter of the substrate, and said three rollers are operable to press the edge portion of the substrate toward a center of the substrate while rotating the substrate.

(NAME OF DOCUMENT) SPECIFICATION

(TITLE OF THE INVENTION) SUBSTRATE HOLDING APPARATUS

(TECHNICAL FIELD TO WHICH THE INVENTION BELONGS)

(0001)

The present invention relates to a substrate holding apparatus for holding and rotating a substrate such as a semiconductor wafer, and more particularly to a substrate holding apparatus suitable for use in a cleaning apparatus, an etching apparatus, or the like.

(BACKGROUND ART)

(0002)

In semiconductor fabrication processes, a surface of a substrate, such as a semiconductor wafer, is required to be highly clean. This is because particles (e.g., semiconductor fine particles or dust) on the surface of the semiconductor wafer could exert a bad influence on the subsequent processes (e.g., film-forming process and exposure process), causing defects including a short circuit. Thus, in order to avoid such problems, a cleaning process is performed on the semiconductor wafer using a processing liquid (cleaning liquid) or roll sponges, while the substrate is being held and rotated by a substrate holding apparatus, to thereby remove the particles from the surface of the semiconductor (see patent documents 1 and 2).

(0003)

In the semiconductor fabrication processes, sputtering, CVD (chemical vapor deposition), or plating is used for forming a thin film of Cu or other materials on the semiconductor wafer. The thin film on a periphery of the semiconductor wafer can spread via a transfer robot when the semiconductor wafer is transferred, causing a so-called cross contamination. Thus, an etching process is performed so as to selectively remove the thin film on the periphery and a rear surface of the semiconductor wafer. In this etching process, a processing liquid (etching liquid) is supplied onto the periphery and the rear surface of the semiconductor wafer, while the semiconductor wafer is being rotated by the substrate holding apparatus.

(0004)

FIG. 11 is a plan view schematically showing a conventional substrate holding apparatus for use in the cleaning process or the etching process. As shown in FIG. 11, the substrate holding

apparatus comprises rollers 50a, 50b, 50c and 50d (hereinafter collectively referred to as rollers 50) for holding a semiconductor wafer W horizontally and rotating the semiconductor wafer W. The respective rollers 50 are moved in parallel with each other in directions indicated by arrows in FIG. 11 and rotated by motors as drive sources (not shown). When the semiconductor wafer W is transferred to the substrate holding apparatus, the four rollers 50 are moved toward the semiconductor wafer W to press an edge portion of the semiconductor wafer W. The semiconductor wafer W is thus held by being held in close contact with the rollers 50. While holding the semiconductor wafer W, the rollers 50 are rotated by the motors, whereby the semiconductor wafer W is rotated.

(0005)

Patent document 1 Japanese patent publication No. 10-180198

Patent document 2 Japanese patent publication No. 2000-539

**(DISCLOSURE OF THE INVENTION)**

**(PROBLEMS TO BE SOLVED BY THE INVENTION)**

(0006)

However, in the conventional substrate holding apparatus shown in FIG. 11, the rollers 50 are not disposed at equal intervals along the edge portion of the semiconductor wafer W, and are moved in parallel with each other so as to press the edge portion of the semiconductor wafer W. Therefore, a resultant of pressing forces applied from the rollers 50 to the semiconductor wafer W does not become zero at a central portion of the semiconductor wafer W. Accordingly, when the semiconductor wafer W is held and rotated by the rollers 50, stability of a position of a rotational center of the semiconductor wafer W is worsened. Further, contact positions between the rollers 50 and the edge portion of the semiconductor wafer W vary upwardly and downwardly while the substrate is being rotated to cause the whole semiconductor wafer W to be fluctuated and inclined. If a rotational accuracy of the semiconductor wafer W is worsened, a processing liquid, which has been supplied onto the semiconductor wafer W, does not spread uniformly over the surface of the semiconductor wafer W. As a result, the uniform process cannot be performed on the semiconductor wafer W. Further, the semiconductor wafer W being rotated is likely to be easily disengaged from the rollers 50. Therefore, it is necessary to increase the pressing forces applied from the rollers 50 to the semiconductor wafer W, thus accelerating wear of the rollers 50.

(0007)

In addition, if the rotational accuracy of the semiconductor wafer W is worsened, an etching liquid (i.e., a processing liquid) enters not only a back surface and the peripheral portion of the semiconductor wafer W, but also an area where circuits (devices) are formed. As a result, a portion, which is not to be processed, is processed by the etching liquid. Further, the processing liquid (e.g., the etching liquid or the cleaning liquid) is accumulated in clamp portions (recessed portions) of the rollers 50 and is scattered in a direction tangential to the semiconductor wafer W or the rollers 50 as the semiconductor wafer W is rotated, thus causing contamination of the atmosphere and the semiconductor wafer W.

(0008)

It is an object of the present invention to provide a substrate holding apparatus which can improve a rotational accuracy of the substrate, and can prevent wear of rollers and also prevent the processing liquid from being scattered.

**(MEANS FOR COLVING THE PROBLEMS)**

(0009)

In order to achieve the above object, the present invention provides a substrate holding apparatus for holding a substrate, comprising: a plurality of rollers which are brought into contact with an edge portion of a substrate so as to hold and rotate the substrate, wherein said rollers are movable in a radial direction of the substrate.

In a preferred aspect of the present invention, said rollers are disposed at equal intervals in a circumferential direction of the substrate.

(0010)

According to the present invention, the forces, applied from the rollers to the substrate, can be directed to the center of the substrate. Therefore, stability in a position of a rotational center of the substrate can be improved and accuracy in rotation of the substrate can be improved. Further, the substrate is prevented from being disengaged from the rollers during the rotation.

(0011)

In a preferred aspect of the present invention, at least one of said rollers presses the edge portion of the substrate toward a center of the substrate while rotating the substrate.

According to the present invention, wear of the rollers can be suppressed. It is preferable to lower all pressing forces of the rollers and equalize forces applied from the rollers to the substrate.

It is also preferable that the rollers are disposed at equal intervals in the circumferential direction of the substrate so that a resultant of the forces applied from the rollers to the substrate is zero. With this structure, the rotational accuracy can be improved and thus the substrate is prevented from being disengaged from the rollers during the rotation.

(0012)

In a preferred aspect of the present invention, each of circumferential surfaces of said rollers has a groove-like clamp portion which is brought into contact with the edge portion of the substrate, and a width of said clamp portion is not more than twice a thickness of the substrate.

According to the present invention, a position at which the clamp portion and the substrate are held in contact can be stabilized. Hence, the substrate can be held horizontally and rotated without being fluctuated and inclined.

(0013)

In a preferred aspect of the present invention, the clamp portion has a flat section positioned centrally in the clamp portion and two curved sections positioned adjacent to upper and lower ends of the flat section, and a width of the flat section is not more than half the thickness of the substrate.

According to the present invention, the two curved sections can prevent a position of the substrate from being deviated from a center of the clamp portion. Therefore, a relative position between the rollers and the substrate held by the rollers can be reproduced accurately. The curved sections can reduce a space between the substrate and each of the clamp portions. Therefore, an amount of the processing liquid retained in the space can be reduced, and hence scattering of the processing liquid can be suppressed.

(0014)

In a preferred aspect of the present invention, distances between contact points where three of said rollers are held in contact with the substrate are smaller than a diameter of the substrate, and said three rollers are operable to press the edge portion of the substrate toward a center of the substrate while rotating the substrate.

(EFFECT OF THE INVENTION)

(0015)

According to the present invention, because the rotational accuracy of the substrate can be improved, a processing liquid can be supplied uniformly onto the surface of the substrate, and hence uniformity and stability of the process can be improved. Further, because the forces applied from the rollers to the substrate can be lowered, wear of the rollers can be suppressed. Furthermore, because an amount of the scattering processing liquid can be reduced, the atmosphere and the substrate can be prevented from being contaminated.

(BEST MODE FOR PERFORMING THE PRESENT INVENTION)

(0016)

Embodiments of the present invention will be described with reference to the drawings.

FIG. 1 is a plan view schematically showing a substrate holding apparatus according to a first embodiment of the present invention. FIG. 2 is a cross-sectional view taken along line II - II of FIG. 1. In this embodiment, a semiconductor wafer is used as a substrate.

(0017)

As shown in FIG. 1, the substrate holding apparatus has four rollers 1a, 1b, 1c and 1d (which will collectively be referred to as rollers 1) for horizontally holding and rotating a semiconductor wafer W. The rollers 1 are movable in directions defined by guide rails 2a, 2b, 2c and 2d which extend in a radial direction of the semiconductor wafer W. Specifically, as indicated by the arrows in FIG. 1, the respective rollers 1 are movable in the radial direction of the semiconductor wafer W toward a center C of the semiconductor wafer W. Air cylinders 3a, 3b, 3c and 3d (which will collectively be referred to as air cylinders 3) as moving mechanisms are connected to the respective rollers 1 for moving the rollers 1 in the radial direction of the semiconductor wafer W to bring the rollers 1 into and out of contact with an edge portion of the semiconductor wafer W. The rollers 1 are spaced from each other at equal intervals in a circumferential direction of the semiconductor wafer W. The rollers 1 are connected to motors (not shown) as drive sources. When the motors are energized, the respective rollers 1 are rotated synchronously in the same direction.

(0018)

As shown in FIGS. 1 and 2, the substrate holding apparatus has stoppers 4a and 4b for stopping movement of the rollers 1a and 1b which are to be brought into contact with one half of the

semiconductor wafer W which is divided by a central line CL. In FIG. 2, only the stopper 4a is illustrated. The rollers 1a and 1b are moved toward the center C of the semiconductor wafer W under a first pressing force applied from the air cylinders 3a and 3b until the rollers 1a and 1b are brought into contact with the stoppers 4a and 4b. The rollers 1a and 1b are fixed in predetermined positions given in advance by the stoppers 4a and 4b. On the other hand, the rollers 1c and 1d, which are positioned at the other half of the semiconductor wafer W, are moved toward the center C of the semiconductor wafer W without being restricted in their movement under a second pressing force, which is smaller than the first pressing force, applied from the air cylinders 3c and 3d.

(0019)

FIG. 3 is an enlarged cross-sectional view showing an essential part of the roller shown in FIG. 2.

As shown in FIG. 3, the roller 1a has a groove-like clamp portion 5 positioned near an upper end thereof and extending along a circumferential surface of the roller 1a. The clamp portion 5 has a flat section 5a positioned centrally and two curved sections 5b positioned adjacent to upper and lower ends of the flat section 5a, and has a substantially arcuate cross-sectional shape as a whole. With this structure, when the roller 1a is moved toward the semiconductor wafer W, the flat section 5a is brought into contact with the edge portion of the semiconductor wafer W in such a state that the clamp portion 5 accommodates a peripheral portion of the semiconductor wafer W. The peripheral portion of the semiconductor wafer W is a region ranging from the edge portion of the semiconductor wafer W to a portion located radially inwardly of the edge portion by a distance of 0.1 mm to several mm. Although not shown, the rollers 1b, 1c and 1d also have clamp portions 5, as well as the roller 1a. The semiconductor wafer W is held by the rollers 1a, 1b, 1c and 1d via those clamp portions 5. The rollers 1 have the same shape and the same size as each other. The rollers 1 are made of a fluororesin such as PVDF or PEEK, which has a chemical resistance, or polyurethane.

(0020)

The clamp portion 5 has a width (vertical length) E which is not more than twice a thickness T of the semiconductor wafer W. Specifically, if the semiconductor wafer W has a diameter of 200 mm and a thickness of 0.75 mm, then the width E of the clamp portion 5 is set to be

not more than 1.5 mm. The flat section 5a has a width (vertical length) F which is not more than half the thickness T of the semiconductor wafer W. With this configuration, the semiconductor wafer W held by the clamp portion 5 is restricted to the position of the flat section 5a by the curved sections 5b. Therefore, the semiconductor wafer W can be rotated while its attitude is being kept substantially constant.

(0021)

The substrate holding apparatus has a height adjusting mechanism (not shown) for adjusting a height of each roller 1 and a tilt adjusting mechanism (not shown) for adjusting a tilt of each roller 1. The height adjusting mechanism and the tilt adjusting mechanism can allow the clamp portions 5 of all the rollers 1 to be kept in parallel with each other in the same horizontal plane.

(0022)

Operation of the substrate holding apparatus thus constructed will be described below.

When the semiconductor wafer W is introduced into the substrate holding apparatus by a transfer robot or the like, the four rollers 1 are moved toward the center C of the semiconductor wafer W. The rollers 1a and 1b are brought into contact with the stoppers 4a and 4b, respectively, and their movements are thus stopped, whereby the rollers 1a and 1b are fixed in position. On the other hand, the rollers 1c and 1d are brought into contact with the edge portion of the semiconductor wafer W, and press the semiconductor wafer W toward the center C of the semiconductor wafer W under a predetermined pressing force, e.g., a pressing force (second pressing force) of 20 N or less. In this manner, the clamp portions 5 (the flat sections 5a) of the four rollers 1 are held in contact with the edge portion of the semiconductor wafer W. Hence, the semiconductor wafer W is securely held by the rollers 1. While the semiconductor wafer W is being thus held by the rollers 1, the motors are energized to rotate the rollers 1 synchronously in the same direction, thereby rotating the semiconductor wafer W.

(0023)

In order to keep the position of the semiconductor wafer W held by the rollers 1 constant, it is necessary to fix the positions of the rollers 1a and 1b with the stoppers 4a and 4b. It is also necessary that the second pressing force applied by the air cylinders 3c and 3d to press the rollers 1c and 1d is smaller than the first pressing force applied by the air cylinders 3a and 3b to press the rollers 1a and 1b. Specifically, in this embodiment, the second pressing force for pressing the

rollers 1c and 1d which are held in contact with one half of the semiconductor wafer W which is divided by the central line CL is smaller than the first pressing force for pressing the rollers 1a and 1b which are held in contact with the other half of the semiconductor wafer W. With this arrangement, the rollers 1c and 1d can press the semiconductor wafer W while the rollers 1a and 1b are fixed in position by being held in contact with the stoppers 4a and 4b. Therefore, a center of rotation of the semiconductor wafer W can be kept in a constant position.

(0024)

Further, according to the present embodiment, directions of the forces acting from the rollers 1 on the semiconductor wafer W can converge on the center C of the semiconductor wafer W. In this state, since the respective rollers 1 are disposed at equal intervals in the circumferential direction of the semiconductor wafer W, resultant of the forces acting from the rollers 1 toward the center C of the semiconductor wafer W becomes substantially zero. Therefore, positional variation of the center of rotation of the semiconductor wafer W can be suppressed. Since the width E of the clamp portion 5 is set to not more than twice the thickness T of the semiconductor wafer W and each of the clamp portions 5 comprises the flat section 5a and the curved sections 5b, the semiconductor wafer W and the clamp portions 5 are held in contact with each other at substantially constant positions, thus preventing the semiconductor wafer W from being moved vertically. Therefore, the semiconductor wafer W can be prevented from being largely fluctuated or tilted while being rotated. The substrate holding apparatus according to the present embodiment is thus capable of increasing a rotational accuracy of the semiconductor wafer W

(0025)

In this embodiment, the pressing force of the rollers 1c and 1d applied to the semiconductor wafer W is set to be not more than 20 N. However, this pressing force should preferably be adjusted depending on the size of the semiconductor wafer W and the number of rollers that have been installed. Although the substrate holding apparatus of this embodiment has the four rollers 1, at least three rollers may be provided in the substrate holding apparatus. A distance between contact points where adjacent two of the rollers 1 are held in contact with the semiconductor wafer W is set to be smaller than a diameter of the semiconductor wafer W. For example, in a case where the substrate holding apparatus has three rollers, then these rollers are disposed such that each of the distances between contact points where the three rollers are held in contact with the edge portion of the semiconductor wafer W is smaller than the diameter of the semiconductor wafer W. In this case, the three rollers should preferably press the edge portion of the semiconductor wafer toward the center of the semiconductor wafer under a predetermined pressing force or less while rotating the semiconductor wafer W. By thus pressing the

semiconductor wafer with at least three rollers under the predetermined pressing force or less, the forces acting from the rollers on the semiconductor wafer can be small while maintaining a desired rotational accuracy.

(0026)

A cleaning apparatus incorporating the substrate holding apparatus according to the first embodiment will be described below. FIG. 4 is a side view showing a cleaning apparatus for removing particles which have adhered to a surface of a semiconductor wafer, and also showing the manner in which upper and lower surfaces of the semiconductor wafer W are cleaned. This cleaning apparatus has the substrate holding apparatus shown in FIG. 1, and has air cylinders and guide rails (not shown) for allowing the rollers 1 to move in the radial direction of the semiconductor wafer W.

(0027)

As shown in FIG. 4, an upper-surface-side cleaning nozzle 12 is supported by an elevating/lowering mechanism (not shown), and arranged close to the upper surface of the semiconductor wafer W. A lower-surface-side cleaning nozzle 15 is similarly disposed close to the lower surface of the semiconductor wafer W at a predetermined height. The lower-surface-side cleaning nozzle 15 is also supported by an elevating/lowering mechanism (not shown). The semiconductor wafer W is held horizontally by the substrate holding apparatus shown in FIG. 1. A cleaning liquid is supplied from the upper-surface-side cleaning nozzle 12 and the lower-surface-side cleaning nozzle 15 to the rotating semiconductor wafer W, thereby cleaning the upper surface and lower surface of the semiconductor wafer W. A distance between the upper-surface-side cleaning nozzle 12 and the upper surface of the semiconductor wafer W and a distance between the lower-surface-side cleaning nozzle 15 and the lower surface of the semiconductor wafer W are preferably not more than 2 mm, more preferably not more than 0.5 mm. Only one of the upper-surface-side cleaning nozzle 12 and the lower-surface-side cleaning nozzle 15 may be provided.

(0028)

Gas supply nozzles 13 and 14 are disposed at the upper surface side and the lower surface side of the semiconductor wafer W, respectively, so that a drying gas, such as an inert gas (e.g., an N<sub>2</sub> gas) or a dry air having a humidity of not more than 10 %, is supplied from each of the gas

supply nozzles 13 and 14 to the semiconductor wafer W. In FIG. 4, the upper-surface-side gas supply nozzle 13 and the lower-surface-side gas supply nozzle 14 are in retreat positions, respectively. After the semiconductor wafer W is cleaned, the upper-surface-side cleaning nozzle 12 is moved in the radial direction of the semiconductor wafer W to a retreat position, and the upper-surface-side gas supply nozzle 13 is moved to a position above the upper surface of the semiconductor wafer W and then supplies the drying gas to the semiconductor wafer W to dry the semiconductor wafer W. Similarly, the lower-surface-side cleaning nozzle 15 is moved in the radial direction of the semiconductor wafer W to a retreat position below the semiconductor wafer W, and the lower-surface-side gas supply nozzle 14 is moved to a predetermined position and supplies a drying gas to the lower surface of the semiconductor wafer W to dry the semiconductor wafer W.

(0029)

FIG. 5(a) is an enlarged view showing the cleaning nozzle, FIG. 5(b) is a cross-sectional view taken along line Vb-Vb in FIG. 5(a), and FIG. 5(c) is a cross-sectional view taken along line Vc-Vc in FIG. 5(a). As shown in FIGS. 5(a) through 5(c), each of the cleaning nozzles 12 and 15 has an operation surface K1 (first operation section) and an operation surface K2 (second operation section). Each of the operation surfaces K1 and K2 has fluid supply ports 27 and fluid suction ports 28 which are aligned alternately and linearly at predetermined intervals. For example, when cleaning a semiconductor wafer W having a diameter of 200 mm, ten fluid supply ports 27 and ten fluid suction ports 28 are arranged alternately.

(0030)

As shown in FIG. 5(c), each of the fluid supply ports 27 is connected to a common supply pipe (supply passage) 29. With this structure, when the cleaning liquid is supplied to the supply pipe 29, the cleaning liquid is supplied from the respective fluid supply ports 27 to the surface of the semiconductor wafer W. As shown in FIG. 5(b), each of the fluid suction ports 28 is connected to a common discharge pipe (discharge passage) 30. The discharge pipe 30 is connected to a vacuum source and evacuated by the vacuum source, so that the cleaning liquid, which has been supplied to the surface of the substrate, is sucked through the respective fluid suction ports 28. In the illustrated embodiment, each of the cleaning nozzles 12 and 15 has two

operation surfaces K1 and K2. This structure allows the respective cleaning nozzles 12 and 15 to use two types of fluids.

(0031)

In this cleaning apparatus shown in FIGS. 4 and 5, the fluid supply ports 27 supply the cleaning liquid to the semiconductor wafer W, and the fluid suction ports 28 suck the cleaning liquid which has been supplied to the semiconductor wafer W. The cleaning nozzles 12 and 15 are moved repeatedly in the radial direction of the semiconductor wafer W and perform supply and suction of the cleaning liquid to thereby clean the semiconductor wafer W. This cleaning process is effective in preventing the scattering of the cleaning liquid from the semiconductor wafer W and minimizing an amount of the cleaning liquid remaining on the processed semiconductor wafer W.

(0032)

FIG. 6(a) is a plan view showing another example of the cleaning apparatus incorporating the substrate holding apparatus according to the first embodiment. FIG. 6(b) is a side view of the cleaning apparatus shown in FIG. 6(a). Structure and operation of this example, which will not be described below, are identical to those of the cleaning apparatus shown in FIGS. 4 and 5, and identical structural components are denoted by the same reference numerals and will not be described below.

(0033)

In this cleaning apparatus, only a cleaning nozzle 15 is disposed below the semiconductor wafer W, and a purge plate 38, which is horizontally and vertically movable, is disposed above the semiconductor wafer W. The purge plate 38 has at least one opening (not shown) for supplying an inert gas such as an N<sub>2</sub> gas to the semiconductor wafer W to prevent a mist of the cleaning liquid or a chemical liquid atmosphere produced at the lower surface of the semiconductor wafer W from contaminating a device area formed on the surface of the semiconductor wafer W. The purge plate 38 may have only one opening at a position corresponding to the center of the semiconductor wafer W or a plurality of openings disposed on a plurality of circles arranged concentrically with the semiconductor wafer W.

(0034)

The cleaning apparatus has a bevel cleaning nozzle 36 for supplying a cleaning liquid to the peripheral portion (bevel portion) of the semiconductor wafer W and a suction nozzle 37 for sucking the cleaning liquid. The bevel cleaning nozzle 36 and the suction nozzle 37 are moved by motors (not shown) in the radial direction of the semiconductor wafer W so that their processing positions can be adjusted. With this structure, the cleaning liquid is supplied from the bevel

cleaning nozzle 36 and is sucked by the suction nozzle 37 immediately before the semiconductor wafer W makes one rotation in the direction indicated by the arrow.

(0035)

The cleaning apparatus according to the embodiment is capable of cleaning the rear surface of the semiconductor wafer W and cleaning the upper-surface-side bevel portion of the semiconductor wafer W. The cleaning apparatus is also capable of increasing a rotational accuracy of the semiconductor wafer W because this cleaning apparatus has the substrate holding apparatus according to the above-mentioned embodiment. Therefore, the bevel cleaning nozzle 36 and the suction nozzle 37 are prevented from contacting the semiconductor wafer W. Further, a relative position between the bevel cleaning nozzle 36 and the semiconductor wafer W can be kept constant. Hence, an area to be supplied with the cleaning liquid can be adjusted accurately. In this case, this area can be adjusted by changing the size of the cross section of the clamp portion 5 (see FIG. 3).

(0036)

The above cleaning apparatus can perform an etching process or other process on the semiconductor wafer W with use of the bevel cleaning nozzle 36 and the suction nozzle 37, and can then perform a cleaning process. The bevel cleaning nozzle 36 and the suction nozzle 37 may be reciprocated in the radial direction of the semiconductor wafer W so as to process the entire surface of the semiconductor wafer W.

(0037)

FIG. 7(a) is an enlarged plan view of one of the rollers shown in FIG. 6(a), and FIG. 7(b) is a cross-sectional view of the roller shown in FIG. 7(a).

In FIGS. 7(a) and 7(b), the cleaning apparatus has a roller cleaning nozzle 26 configured to supply a cleaning liquid (rinsing liquid) to the clamp portion 5 of the roller 1a, and a suction nozzle 24 configured to suck the cleaning liquid (rinsing liquid) supplied to the clamp portion 5. The roller cleaning nozzle 26 has a supply mouth 25 at its tip end thereof, and this supply mouth 25 is located close to the clamp portion 5. Similarly, the suction nozzle 24 has a suction mouth 23 at its tip end thereof, and this suction mouth 23 is located close to the clamp portion 5. The roller cleaning nozzle 26 is arranged in a position forward of a contact point Wc between the clamp portion 5 and the semiconductor wafer W with respect to the rotational direction of the roller 1a.

The suction nozzle 24 is arranged in a position forward of the roller cleaning nozzle 26. It is preferable that a distance between the supply mouth 25 and suction mouth 23 and the clamp portion 5 be not more than 5 mm.

(0038)

The roller cleaning nozzle 26 is coupled to a cleaning-liquid supply source (not shown), so that the cleaning liquid is supplied to the clamp portion 5 through the supply mouth 25. The suction nozzle 24 is coupled to a vacuum source (not shown), and the suction mouth 23 communicates with the vacuum source. While not shown, roller cleaning nozzles 26 and suction nozzles 24 are arranged close to the rollers 1b, 1c, and 1d as well.

(0039)

The roller 1a is rotated in the direction indicated by the arrow, and the supply mouth 25 of the roller cleaning nozzle 26 supplies the cleaning liquid to the clamp portion 5 to thereby clean the clamp portion 5. As the roller 1a is rotated, the cleaning liquid reaches a position in front of the suction mouth 23 of the suction nozzle 24, and is then sucked by the suction nozzle 24. In this manner, since the cleaning liquid is supplied from the roller cleaning nozzle 26 locally to the clamp portion 5, the cleaning liquid is prevented from being scattered from the roller 1a (the clamp portion 5). Further, since relative positions of the roller cleaning nozzle 26 and the suction nozzle 24 with respect to the roller 1a can be kept constant, supply and suction of the cleaning liquid can be performed stably.

(0040)

Next, a back-side etching apparatus incorporating the substrate holding apparatus according to the first embodiment of the present invention will be described with reference to FIG. 8. FIG. 8 is an enlarged cross-sectional view schematically showing an essential part of the back-side etching apparatus incorporating the substrate holding apparatus according to the first embodiment of the present invention.

As shown in FIG. 8, a film 10 is formed on the surface of the semiconductor wafer W. An etching liquid supply nozzle 11 for supplying an etching liquid as a processing liquid to the lower surface of the semiconductor wafer W is disposed below the semiconductor wafer W. In the illustrated embodiment, the clamp portion 5 has a depth D of not more than 1 mm.

(0041)

The semiconductor wafer W is held by the rollers 1 (only the roller 1a is shown in FIG. 8)

in such a state that the surface having the film 10 faces downwardly. While the semiconductor wafer W is being rotated by the rollers 1, the etching liquid is supplied from the etching liquid supply nozzle 11 to the lower surface (back surface) of the semiconductor wafer W. The etching liquid supplied to the lower surface of the semiconductor wafer W reaches the lower-surface-side peripheral portion as the semiconductor wafer W is rotated. Thus, the film 10 formed on the lower surface of the semiconductor wafer W is removed by the etching liquid. A part of the etching liquid enters the upper surface of the semiconductor wafer W via the clamp portions 5, and the peripheral portion of the upper surface of the semiconductor wafer W is exposed to the etching liquid.

(0042)

In this embodiment, since the depth D of the clamp portion 5 is not more than 1 mm, a space between the peripheral portion of the semiconductor wafer W and the clamp portion 5 of the roller 1a can be further reduced. Therefore, an amount of the etching liquid that fills the above space is reduced, and hence an amount of the etching liquid flowing from the lower surface to the upper surface of the semiconductor wafer W is also reduced. Further, since the depth D of the clamp portion 5 is set to be not more than 1 mm, the semiconductor wafer W is exposed to the etching liquid in a limited region ranging from the edge portion of the semiconductor wafer W to a portion located radially inwardly of the edge portion by a maximum of 2 mm. Therefore, it is possible to prevent the etching liquid from entering an area where a circuit (device) is formed on the semiconductor wafer W. Furthermore, since the amount of the etching liquid filling the above-mentioned space is reduced, the amount of the etching liquid, which is scattered around when the semiconductor wafer W is rotated, can be also reduced.

(0043)

The substrate holding apparatus according to the present embodiment can be applied to a cleaning apparatus for physically or chemically removing particles which have adhered to a surface of a semiconductor wafer, an etching apparatus for removing a thin film such as a metal film formed on a peripheral portion and a lower surface of a semiconductor wafer, and a drying apparatus for supplying an inert gas or a dehumidified air to a surface of a semiconductor wafer to dry the semiconductor wafer. The substrate holding apparatus according to the present invention is capable of increasing the rotational accuracy of the semiconductor wafer (i.e., substrate). Hence, a

various processes can be performed on the semiconductor wafer without bringing the semiconductor wafer into contact with nozzles disposed near the semiconductor wafer.

(0044)

A second embodiment of the present invention will be described below with reference to FIG. 9. FIG. 9 is a plan view schematically showing a substrate holding apparatus according to the second embodiment of the present invention. Structure and operation of the substrate holding apparatus according to the second embodiment are the same as those of the substrate holding apparatus according to the first embodiment, and identical components will not be described below. The second embodiment is different from the first embodiment mainly in that while the four air cylinders are used in the first embodiment, two air cylinders are used in the second embodiment.

(0045)

As shown in FIG. 9, the rollers 1a, 1b, 1c and 1d are mounted respectively on mount bases 6a, 6b, 6c and 6d. The mount base 6a is provided on two parallel guide rails 2a and 2a, so that movements of the mount base 6a and the roller 1a are regulated in the radial direction of the semiconductor wafer W. Like the mount base 6a, the mount bases 6b, 6c and 6d are provided respectively on parallel guide rails 2b and 2b, parallel guide rails 2c and 2c, and parallel guide rails 2d and 2d, so that movements of the mount bases 6b, 6c and 6d and the rollers 1b, 1c and 1d are regulated in the radial direction of the semiconductor wafer W.

(0046)

Link plates 7a and 7b are disposed between the mount bases 6a and 6b and between the mount bases 6c and 6d, respectively. The link plates 7a and 7b are coupled respectively to air cylinders 3a and 3b, which move the link plates 7a and 7b in the radial direction of the semiconductor wafer W. The link plate 7a is coupled to the mount base 6a by a cam follower 8a and a cam follower receiver 9a which engage each other, and is also coupled to the mount base 6b by a cam follower 8b and a cam follower receiver 9b which engage each other. The link plate 7b is coupled to the mount base 6c by a cam follower 8c and a cam follower receiver 9c which engage with each other, and is also coupled to the mount base 6d by a cam follower 8d and a cam follower receiver 9d which engage each other.

(0047)

When the link plates 7a and 7b are moved by the respective air cylinders 3a and 3b, the rollers 1a, 1b, 1c and 1d and the mount bases 6a, 6b, 6c and 6d are moved in the radial direction of the semiconductor wafer W toward the center C of the semiconductor wafer W. The movements of the mount bases 6a and 6b are stopped at given positions by respective stoppers 4a and 4b, whereby the rollers 1a and 1b are fixed in position. On the other hand, the mount bases 6c and 6d are moved toward the center C of the semiconductor wafer W without being limited in movement by any stopper. As with the first embodiment, the edge portion of the semiconductor wafer W is held by the four rollers 1 which are arranged at equal intervals in the circumferential direction of the semiconductor wafer W. Hence, the resultant of the forces acting from the rollers 1 toward the center C of the semiconductor wafer W becomes zero. Therefore, the semiconductor wafer W can be rotated at a high rotational accuracy by the rotation of the rollers 1.

(0048)

A substrate holding apparatus according to a third embodiment of the present invention will be described below with reference to FIG. 10.

FIG. 10 is an enlarged cross-sectional view showing an essential part of a roller of the substrate holding apparatus according to the third embodiment of the present invention. Structure and operation of the substrate holding apparatus according to the third embodiment which will not be described below are identical to those of the substrate holding apparatus according to the first embodiment.

(0049)

As shown in FIG. 10, the two curved sections 5b of the clamp portion 5 and a circumferential surface of the roller 1a are smoothly and continuously connected to each other. Specifically, a connect portion between the curved sections 5b and the circumferential surface of the roller 1a extend arcuately. Accordingly, there is no boundary between the curved sections 5b and the circumferential surface of the roller 1a, thus forming no angular portion extending in the circumferential direction of the roller 1a. If an angular portion is present on the circumferential surface of the roller 1a, then the processing liquid tends to be scattered around from the angular portion when the roller 1a is rotated. According to the present embodiment, since the two curved sections 5b and the circumferential surface of the roller 1a are connected smoothly and continuously

to each other, the processing liquid is prevented from being scattered around. In this embodiment also, the space formed between the peripheral portion of the semiconductor wafer W and the two curved sections 5b should preferably be small. Although the clamp portion 5 includes the flat section 5a in this embodiment, it is possible to dispense with the flat section 5a.

(BRIEF DESCRIPTION OF DRAWINGS)

(0050)

(FIG. 1) FIG. 1 is a plan view schematically showing a substrate holding apparatus according to a first embodiment of the present invention.

(FIG. 2) FIG. 2 is a cross-sectional view taken along line II - II of FIG. 1.

(FIG. 3) FIG. 3 is an enlarged cross-sectional view showing an essential part of the roller shown in FIG. 2.

(FIG. 4) FIG. 4 is a side view showing an essential part of a cleaning apparatus according to the first embodiment of the present invention.

(FIG. 5) FIG. 5(a) is an enlarged view showing the cleaning nozzle in FIG. 4, FIG. 5(b) is a cross-sectional view taken along line Vb-Vb in FIG. 5(a), and FIG. 5(c) is a cross-sectional view taken along line Vc-Vc in FIG. 5(a).

(FIG. 6) FIG. 6(a) is a plan view showing another example of the cleaning apparatus incorporating the substrate holding apparatus according to the first embodiment. FIG. 6(b) is a side view of the cleaning apparatus shown in FIG. 6(a).

(FIG. 7) FIG. 7(a) is an enlarged plan view of one of the rollers shown in FIG. 6(a), and FIG. 7(b) is a cross-sectional view of the roller shown in FIG. 7(a).

(FIG. 8)

FIG. 8 is an enlarged cross-sectional view schematically showing an essential part of a back-side etching apparatus incorporating the substrate holding apparatus according to the first embodiment of the present invention.

(FIG. 9)

FIG. 9 is a plan view schematically showing a substrate holding apparatus according to the second embodiment of the present invention.

(FIG. 10)

FIG. 10 is an enlarged cross-sectional view showing an essential part of a roller of the substrate holding apparatus according to the third embodiment of the present invention.

(FIG. 11)

FIG. 11 is a plan view schematically showing a conventional substrate holding apparatus.

(EXPLANATION OF THE REFERENCE NUMERALS)

(0051)

1a, 1b, 1c, 1d, 50a, 50b, 50c, 50d    roller

2a, 2b, 2c, 2d    guide rail

3a, 3b, 3c, 3d    air cylinder

4a, 4b    stopper

5    clamp portion

5a    flat section

5b    curved section

6a, 6b, 6c, 6d    mount base

7a, 7b    link plate

8a, 8b, 8c, 8d    cam follower

9a, 9b, 9c, 9d    cam follower receiver

10    film

11    supply nozzle

12, 15    cleaning nozzle

13, 14    gas supply nozzle

23    suction mouth

24    suction nozzle

25    supply mouth

26    roller cleaning nozzle

27    supply mouth

28    suction mouth

29    liquid supply pipe

30    liquid discharge pipe

- 36 bevel cleaning nozzle
- 37 suction nozzle
- 38 purge plate
- W semiconductor wafer (substrate)

(NAME OF DOCUMENT) ABSTRACT

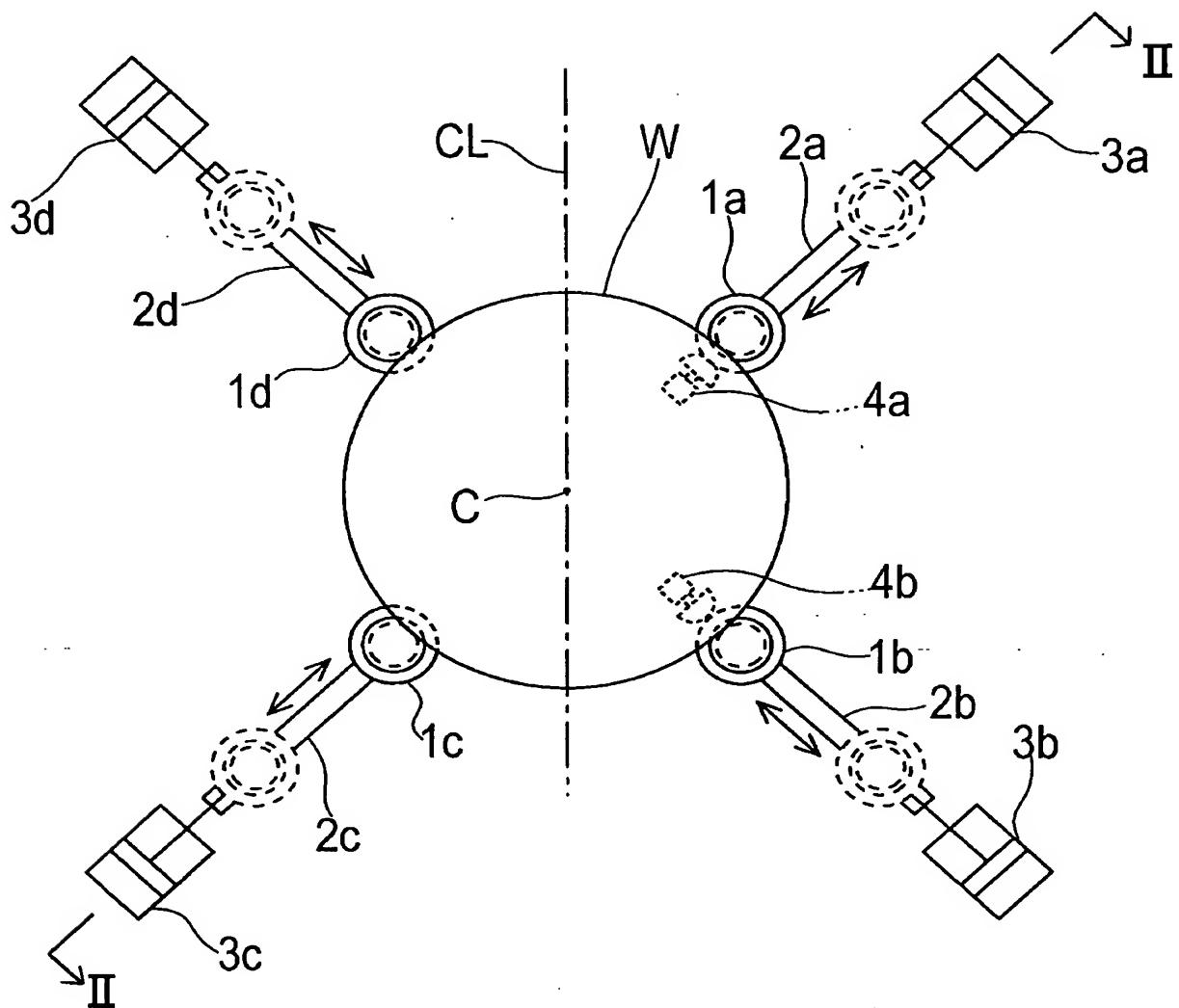
(ABSTRACT)

(PURPOSE) The present invention provides a substrate holding apparatus capable of improving an accuracy in rotation of a substrate and capable of preventing wear of rollers.

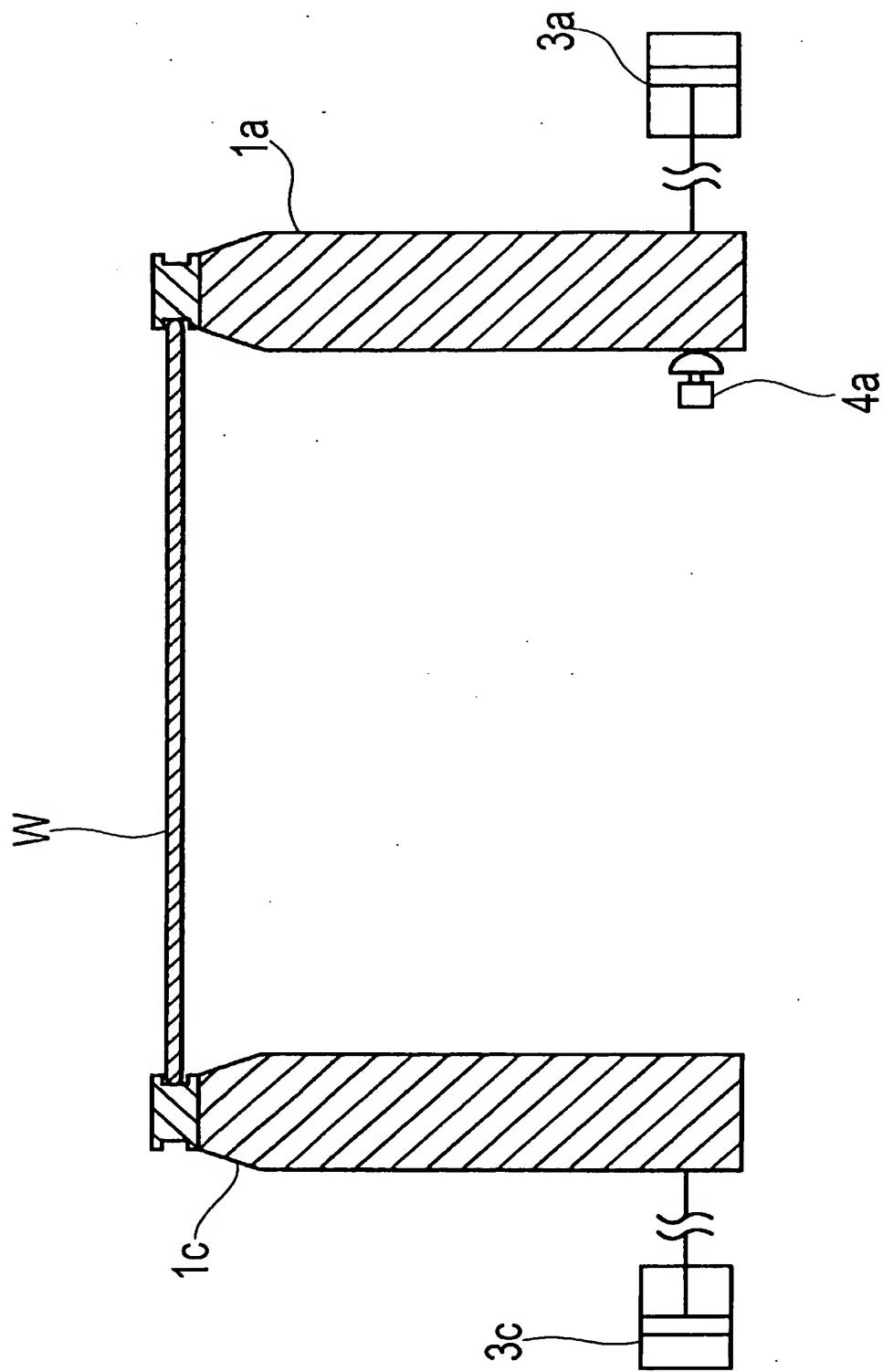
(MEANS FOR SOLUTION) The substrate holding apparatus includes a plurality of rollers 1a, 1b, 1c, 1d which are brought into contact with an edge portion of a semiconductor wafer W so as to hold and rotate the substrate. The rollers 1a, 1b, 1c, 1d are movable in a radial direction of the semiconductor wafer W.

(SELECTED FIGURE) FIG. 1

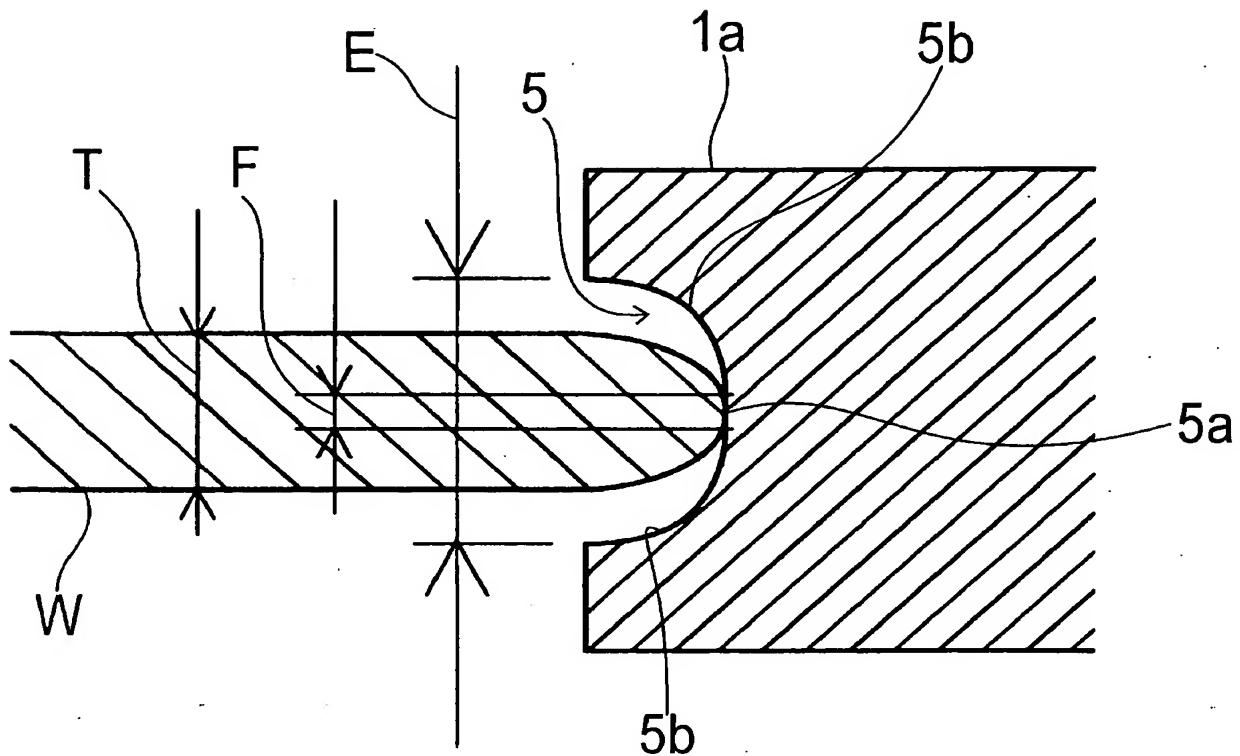
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(NAME OF DOCUMENT) DRAWINGS  
(FIG. 1)



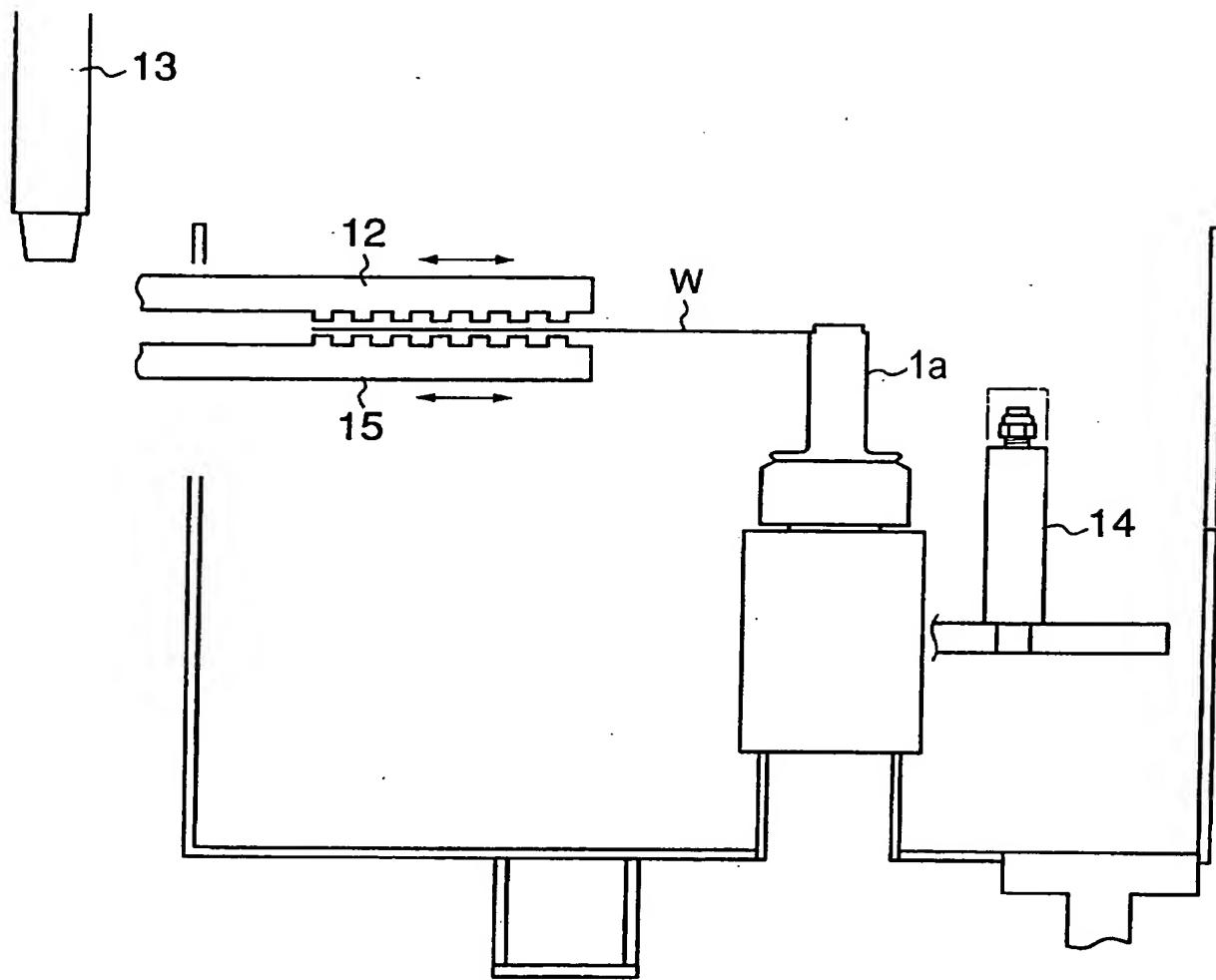
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(FIG. 2)

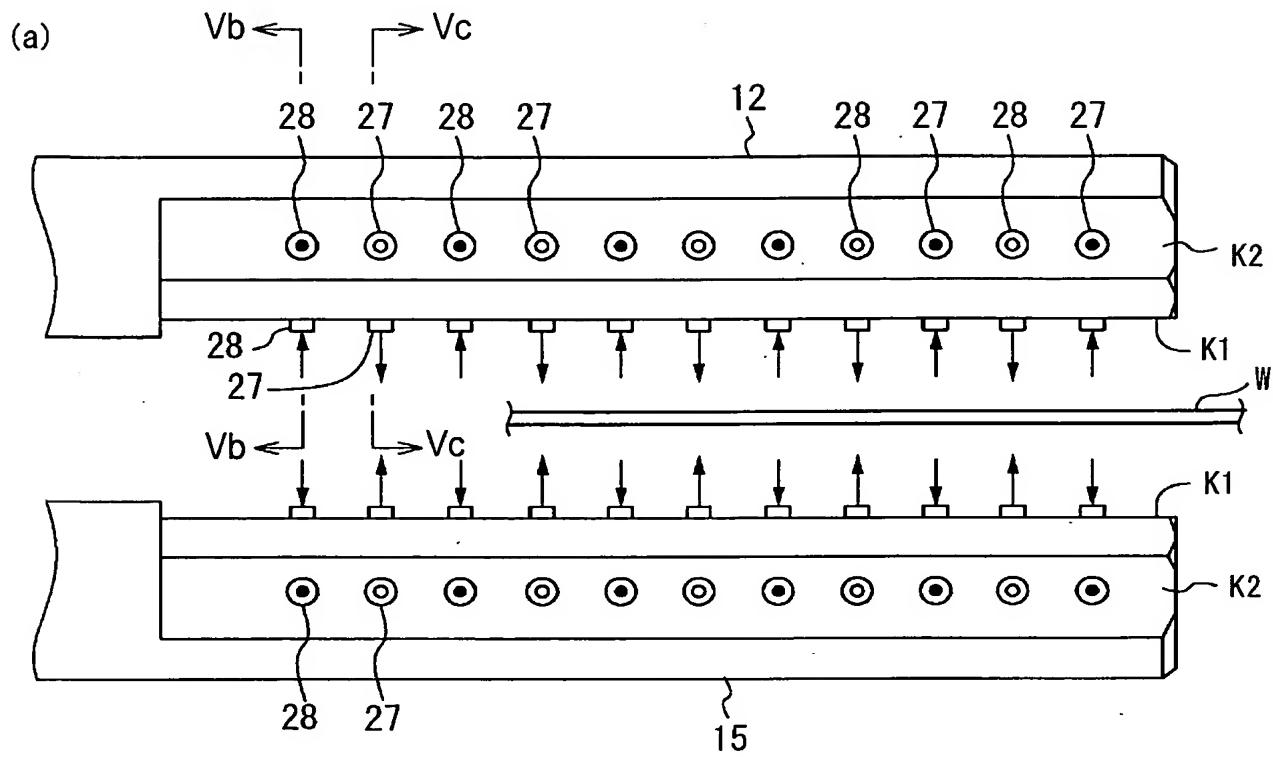


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(FIG. 3)



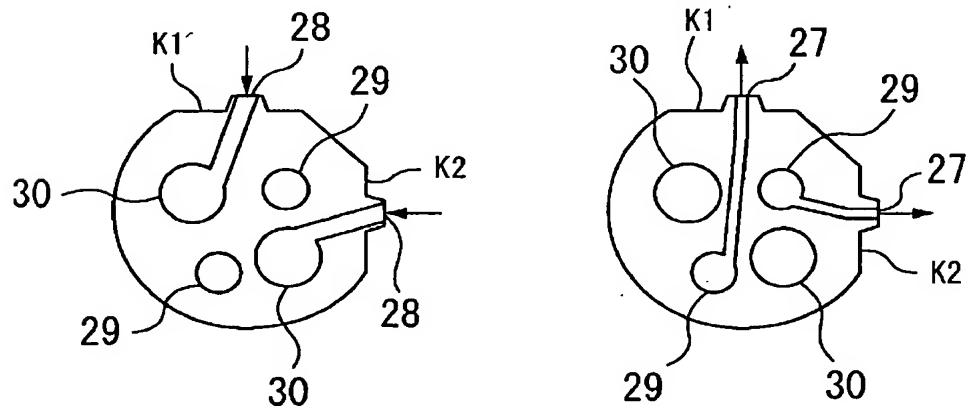
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(FIG. 4)



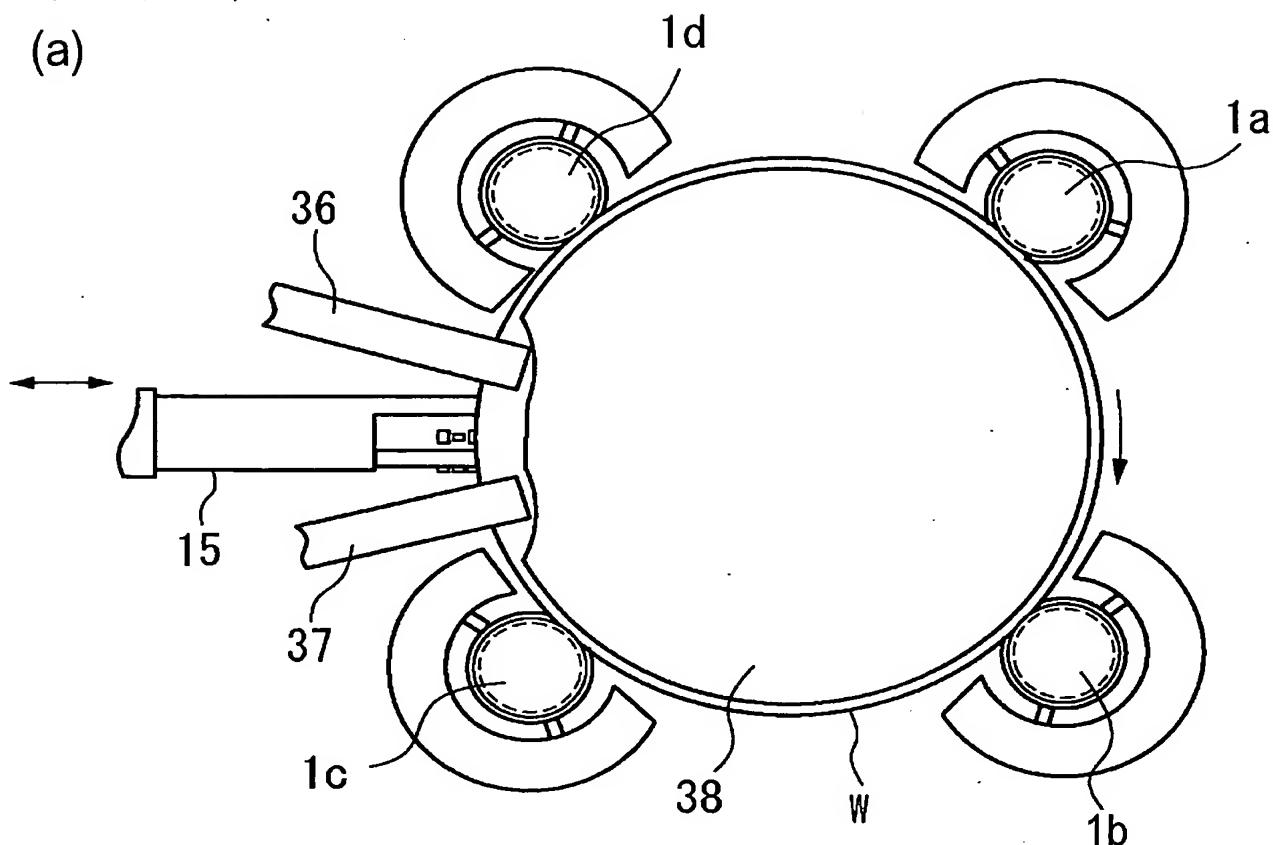


(b)

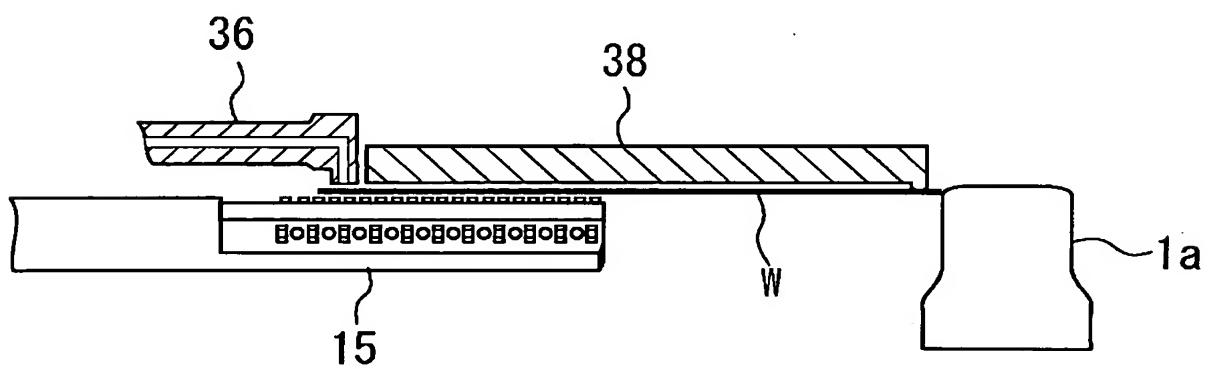
(c)



(a)

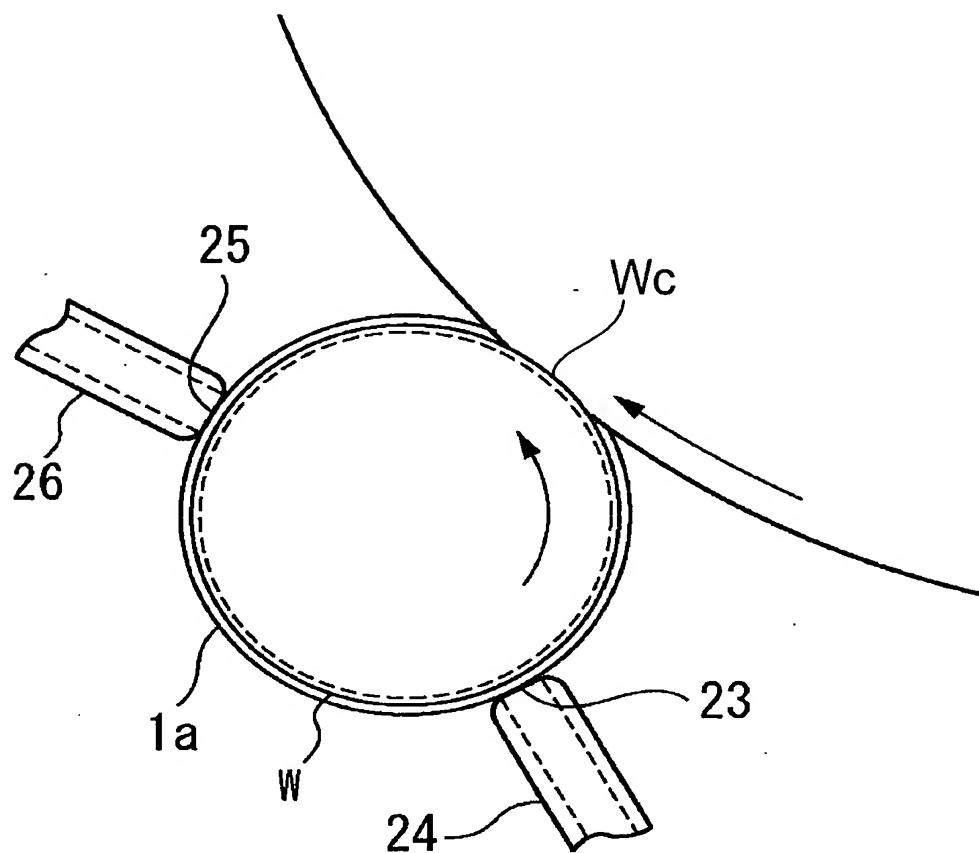


(b)

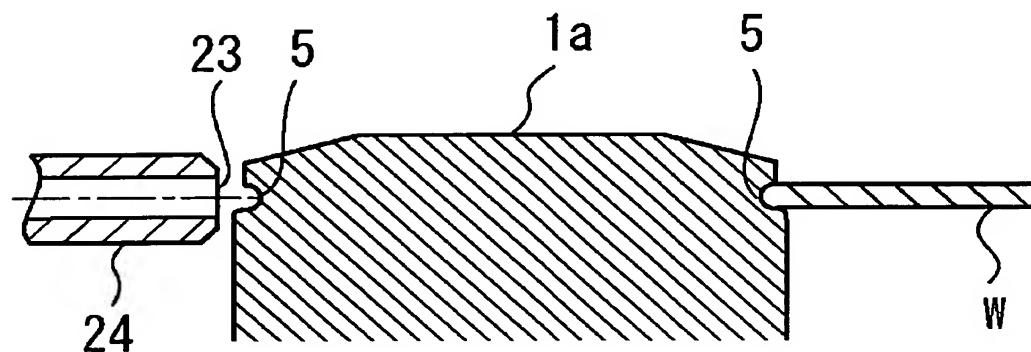


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(FIG. 7)

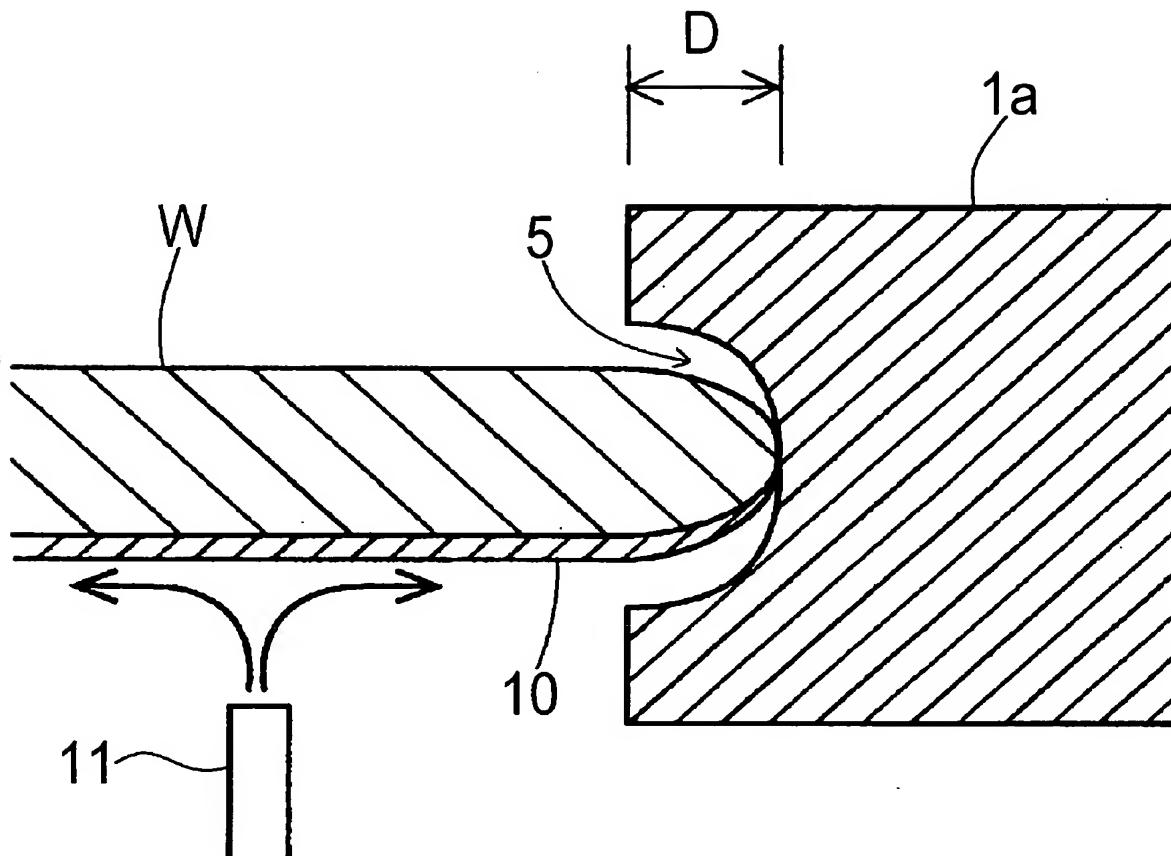
(a)

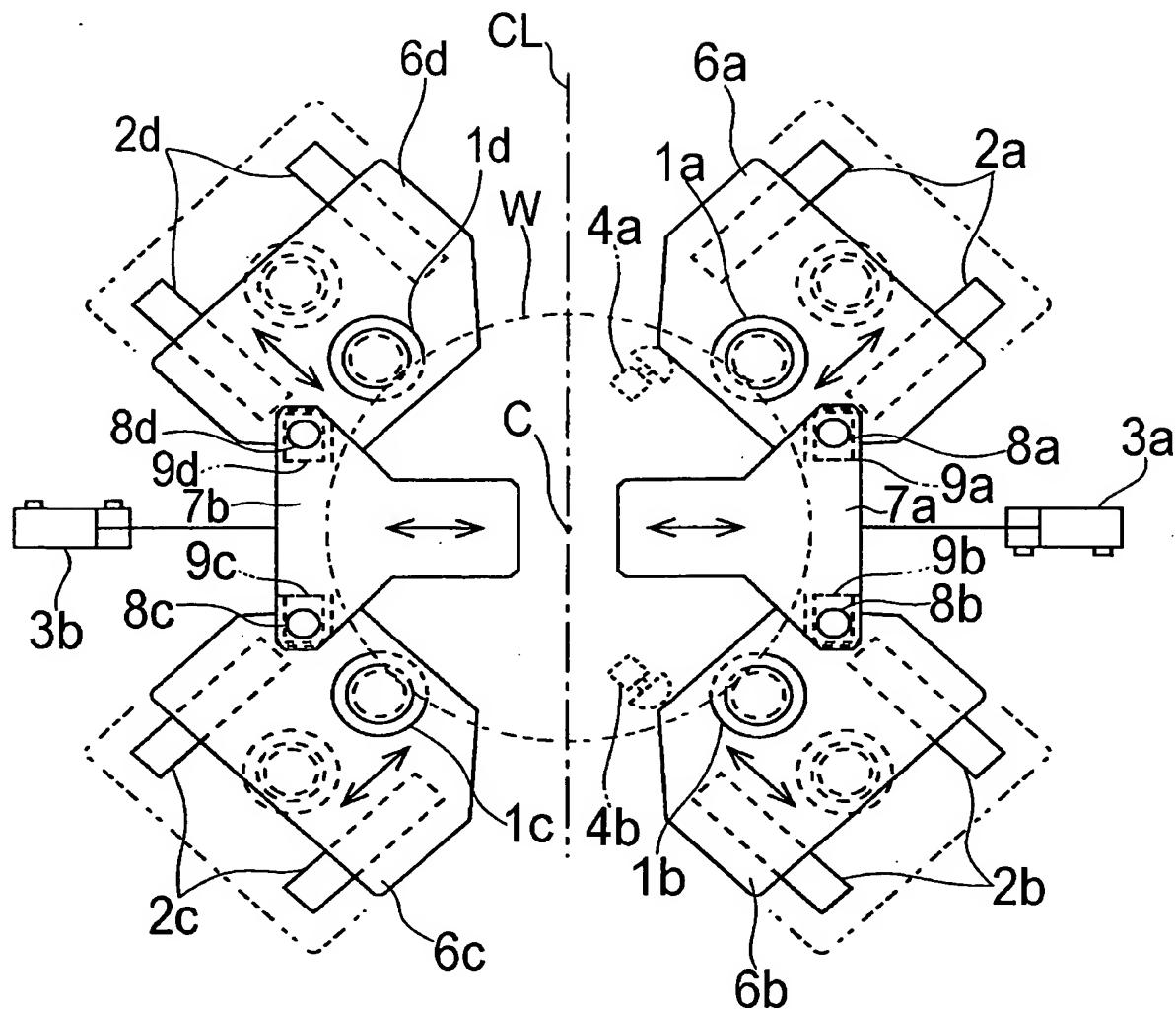


(b)

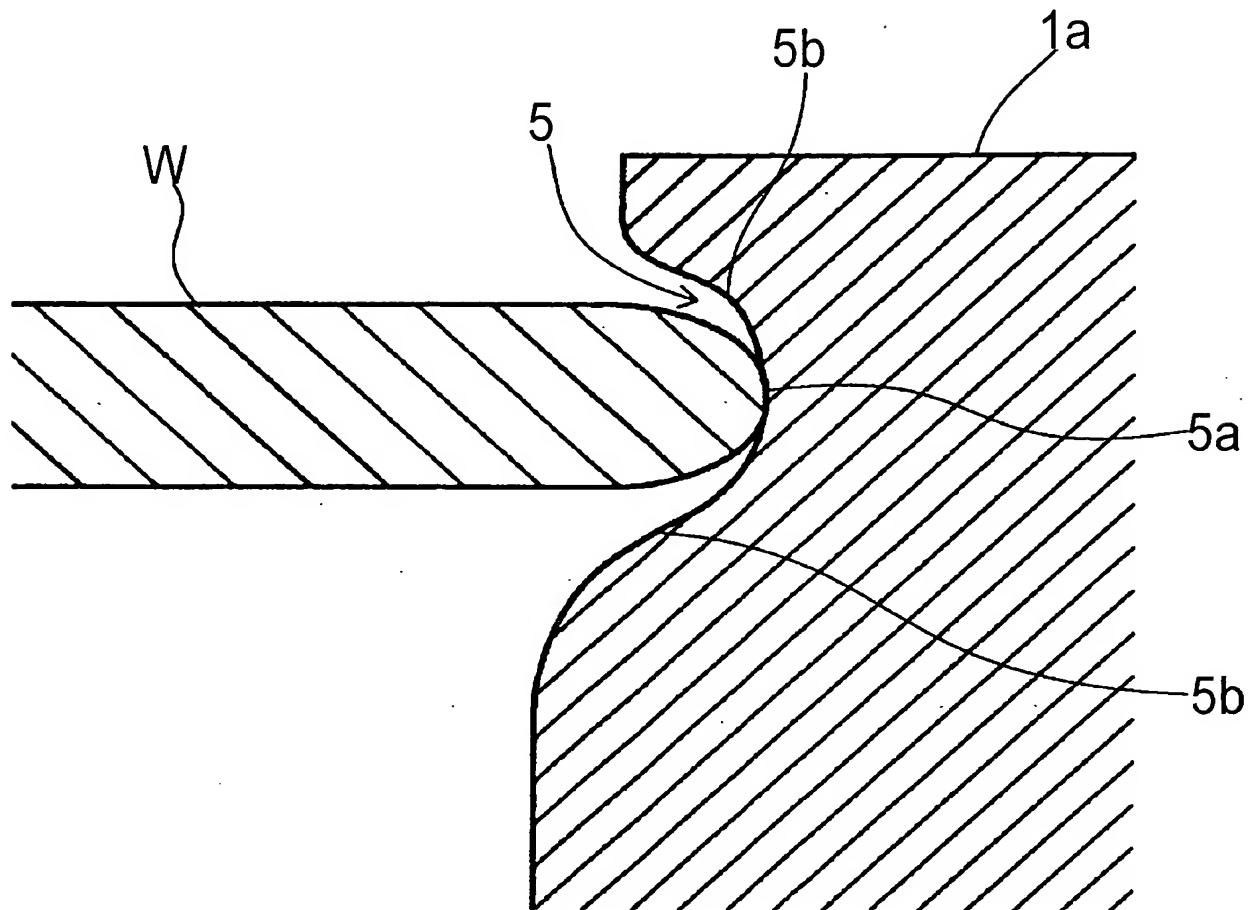


REFERENCE NUMBER EB3180P  
(FIG. 8)





REFERENCE NUMBER EB3180P  
(FIG. 10)



REFERENCE NUMBER EB3180P  
(FIG. 11)

